

1998 AMES FIRE DEPARTMENT  
RESPONSE TIME STUDY

EXECUTIVE DEVELOPMENT

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## **ABSTRACT**

The City of Ames Fire Department has not conducted a formal review of station locations and response times since 1984. The purpose of this research was to analyze current response times and make recommendations if the present two station locations were insufficient to provide adequate emergency fire suppression services.

Historical and action research methods were employed to answer the following questions:

1. Are there regulations, standards, and fire service hazards that define or dictate response times?
2. Do Ames' present two-station scenario and current sites adequately serve the community?
3. Could an additional third or fourth station improve the delivery of fire suppression services?
4. Are there potential partners for fire station site and expense sharing?

The literature review found nationally accepted guidelines for five-minute emergency response times. Increased use of synthetic products has reduced the time necessary for a structure to reach flashover. As a result of increased fuel loads, truss systems used in most structures are exposed to higher temperatures earlier in the fire's progression. The use of truss systems has the potential for rapid failure of floor and roof systems trapping occupants and responders.

Interviews, a review of the Land Use Policy Plan, and analysis of National Fire Incident Reporting System data project continuing growth in population, emergency calls, and acres within Ames' city boundaries.

Results of the Geographic Information System analysis of five scenarios highlight deficiencies in the current two station-response capabilities. Geographic Information System

analysis of current city limits and projected growth areas by the year 2015 show a decline from 78% adequate coverage to 68% in 17 years.

Recommendations include first proceeding with additional research to find three new specific station locations, second, retain current station #1, and third, establishing a total of four stations.

Dialogues with identified site-sharing partners should be initiated.

## TABLE OF CONTENTS



|                                  |    |
|----------------------------------|----|
| ABSTRACT.....                    | ii |
| TABLE OF CONTENTS.....           | iv |
| INTRODUCTION.....                | 1  |
| BACKGROUND AND SIGNIFICANCE..... | 2  |
| LITERATURE REVIEW .....          | 5  |
| PROCEDURES .....                 | 8  |
| RESULTS .....                    | 14 |
| DISCUSSION .....                 | 29 |
| RECOMMENDATIONS.....             | 33 |
| REFERENCE LIST.....              | 36 |

## APPENDICES

|  |    |
|--|----|
| Appendix A - Population projections for City of Ames planning area and Story County<br>from 1990 to 2030.....                            | 38 |
| Appendix B - Housing projections for City of Ames planning area and Story County from<br>1990 to 2030.....                               | 39 |
| Appendix C - Land use projections for City of Ames planning area from 1990 to 2030 .....   | 40 |
| Appendix D - Land Use Policy Plan projections for population growth and National Fire<br>Incident Reporting data from 1983 to 1997 ..... | 41 |
| Appendix E - Test run results for Station #1.....  | 42 |
| Appendix F - Test run results for Station #2.....  | 43 |
| Appendix G - Scenario #1 map of response districts.....  | 44 |
| Appendix H - Scenario #1 map of neighborhood nodes .....   | 45 |
| Appendix I - Scenario #2 map of response districts .....   | 46 |
| Appendix J - Scenario #2 map of neighborhood nodes .....   | 47 |

|  |    |
|--|----|
| Appendix K - Scenario #3 map of response districts.....  | 48 |
| Appendix L - Scenario #3 map of neighborhood nodes.....  | 49 |
| Appendix M - Scenario #4 map of response districts ..... | 50 |
| Appendix N - Scenario #4 map of neighborhood nodes.....  | 51 |
| Appendix O - Scenario #5 map of response districts.....  | 52 |
| Appendix P - Scenario #5 map of neighborhood nodes.....  | 53 |

## TABLES

|   |    |
|---|----|
| Table 1 - Historical and projected growth of area, population, and housing units .....                  | 2  |
| Table 2 - Comparison of population, AFD incident calls, and associated percentages .....                | 3  |
| Table 3 - Definition of response time components .....  | 13 |
| Table 4 - Anticipated increase in rail traffic and train length.....                                    | 19 |
| Table 5 - Historical National Fire Incident Reporting System data for Ames Fire<br>Department .....     | 21 |
| Table 6 - Projections of call levels based upon linear growth trend calculations .....                  | 22 |
| Table 7 - Projections of call levels based upon population increases .....                              | 23 |
| Table 8 - Summary of GIS results for five-minute response districts<br>(current city limits).....       | 28 |
| Table 9 - Summary of GIS results for five-minute response districts<br>(LUPP projections for 2015)..... | 28 |

## FIGURES

|  |    |
|--|----|
| Figure 1 – Percentage of neighborhood nodes in 5-minute response area (1998-2015)..... | 31 |
|--|----|

## INTRODUCTION

The Ames Fire Department (AFD) has, as a continuing process, the responsibility to perform evaluation of its response readiness. On February 9, 1998, City Manager Steve Schainker established performance priorities for the AFD that included, “Working with Manager’s Office to develop citywide emergency response plan [sic], exploring all options, including non-traditional” (personal communication, February 9, 1998). A major problem identified was the lack of a formal review of station locations and response times since December of 1984.

The purpose of this research project is to analyze current response times and make recommendations if deficiencies are found. Historical and action research methods were employed to answer the following questions:

1. Are there regulations, standards, and fire service hazards that define or dictate response times?
2. Do Ames’ present two-station scenario and current sites adequately serve the community?
3. Could an additional third or fourth station improve the delivery of fire suppression services?
4. Are there potential partners for fire station site and expense sharing?

## **BACKGROUND AND SIGNIFICANCE**

### **Population and Trends**

In 1975, the city consisted of 9,602 incorporated acres with a population of 43,561 and 16,890 housing units. Population density was 4.5 persons per acre. In 1995, the city consisted of 10,439 incorporated acres with a population of 48,691 and 18,300 housing units. Population density was 4.7 persons per acre. (Land Use Policy Plan [LUPP], 1997)

Projection for growth by the year 2015 estimates a low of 59,500 to a high of 60,800 residents. Estimates for the number of housing units run from a low of 21,000 to a high of 21,500 units. In order to sustain the increase in population and housing units, the LUPP (1997, pp. 24) estimates an increase in incorporated area through annexation of 3,000 to 3,500 acres.

The LUPP (1997) estimates significant growth in population, housing units, and the incorporated acres. Table 1 lists, in twenty-year increments, the estimated growth and the percentage of growth based on 1975 census figures contained in the LUPP.

Table 1

Historical and projected growth of area, population, and housing units

| <b>Year</b> | <b>Acres</b> | <b>% Growth</b> | <b>Population</b> | <b>% Growth</b> | <b>Housing Units</b> | <b>% Growth</b> |
|-------------|--------------|-----------------|-------------------|-----------------|----------------------|-----------------|
| 1975        | 9,602        | Base            | 43,561            | Base            | 16,890               | Base            |
| 1995        | 10,439       | 9%              | 48,691            | 12%             | 18,300               | 8%              |
| 2015        | 13,939       | 45%             | 60,800            | 40%             | 21,500               | 27%             |

Additional population projections for Ames indicate a range of population growth from 10,809 to 12,109 residents by the year 2015. (Appendix A)

Additional housing projections for Ames indicate a range of growth from 2,700 to 3,200 housing units by the year 2015. (Appendix B)

Land use for residential properties as a percentage of total land available is projected to increase from 17% in 1994 to 21% in 2030. Land use for industrial and commercial use as a percentage of total land available is projected to increase from 3% in 1994 to 5% in 2030.

(Appendix C)

### **Fire Department Incident Summary**

The AFD has maintained a National Fire Incident Reporting System (NFIRS) since 1983.

Table 2 summarizes the increase in emergency response calls in five-year increments between 1983 and 1997. More details are included in Appendix D.

Table 2

Comparison of population, AFD incident calls, and associated percentages

| <b>Year</b> | <b>Population</b> | <b>Total Calls</b> | <b>Fire Calls</b> | <b>Fire Calls<br/>as a % of<br/>Total Calls</b> | <b>Non-fire<br/>Calls</b> | <b>Non-fire<br/>Calls as a<br/>% of Total<br/>Calls</b> |
|-------------|-------------------|--------------------|-------------------|---|---------------------------|---|
| 1983        | 45,251            | 508                | 119               | 23%   | 389                       | 77%   |
| 1988        | 46,633            | 795                | 164               | 21%   | 631                       | 79%   |
| 1992        | 47,766            | 839                | 167               | 20%   | 672                       | 80%   |
| 1997        | 49,277            | 1,385              | 189               | 14%   | 1196                      | 86%   |

During the preceding fifteen years, the population has increased by 8.9%. From 1983 to 1997, the increase in fire department responses was 172.6%. The number of fire calls increased from 119 to 189, for a percentage increase of 58.8%, yet the percentage of fire calls compared to total calls decreased from 23% to 14%. The majority of increase in total calls was the increase in non-fire calls from 389 to 1196 for a total increase of 307.5%.

Much of the increase in total response calls are a result of the department's programs to increase services to the public. New programs for emergency medical services, carbon monoxide detection, hazardous materials spills, and confined space rescue have been developed since 1983.



A significant comparison is the rate of population increase, 8.9%, to the fire call increase of 58.8%.

### **Fire Station Locations**

In 1966, AFD headquarters were located in the City Hall at Fifth Street and Kellogg, and a second station was added at Welch and Chamberlain. A new station was built and one closed when the AFD headquarters were moved to 1300 Burnett in 1979. When the new station opened, three additional firefighters were added to bring the total to 42. Three additional firefighters were added in 1998 for the current total of 45 suppression personnel.

Fire Station #1, AFD headquarters, is located in a predominately residential setting and serves as the first in response for the eastern one-half of Ames. Fire Station #2 is located in a commercial area close to Iowa State University (ISU) and serves as the first in response for the university and the western one-half of Ames.

When Station #2 was built, it was on the southern edge of the developed area locally called "Campustown." In the following years, development occurred south of the station. The development of dormitories, apartments, and retail stores has significantly increased the traffic on Welch Avenue. The increased traffic has caused response problems and increased safety concerns for response units and local pedestrian/vehicular traffic.

This paper was prepared to satisfy the request of the Ames City Manager, Steve Schainker, and the requirements of the applied research report associated with the Executive Development course at the National Fire Academy. This research relates to the Executive Development course by utilizing problem solving methodology to determine the way things are versus the way they should be and as a tool to address service quality.

This research has significant impact on the process of planning for suppression services in the community of Ames. The AFD has had and continues to seek the delivery of prevention and suppression services according to adopted codes, national standards, and legal requirements. This research will provide the basis for evaluation of continuing compliance. By analyzing the present station locations and their related response times, the AFD can plan for the predicted growth of the community. Analysis of potential additional station's increased service levels will establish the basis for future research addressing new station cost justification. Establishing a list of potential station site partners is the beginning of dialogues with potential cross-jurisdiction and private industry sources that may reduce initial and operating costs.

## **LITERATURE REVIEW**

The literature review section focused on historical perspectives related to existing standards for response times and the possible effects response times have on life and property loss.

### **Response Time Standards**

Several studies have been conducted on the effect of response time on reduction of loss of life and property. Peterson (1991, pp. 10-43) states, "As already described, time is another critical factor in the evaluation of public fire protection. It is generally considered that the first-arriving piece of apparatus should be at the emergency scene within five minutes of the sounding of the alarm, since additional minutes are needed to size up the situation, deploy hose lines, initiate search and rescue, etc." Proper training can reduce the time necessary for starting

operations. By positioning apparatus and manpower strategically throughout the community, overall response time of five minutes or less can be attained.

Legislation regulating emergency response time requirements has yet to be enacted. Recommendations and industry standards range from three to six minutes. The Phoenix Fire Department has established a performance goal of a three-minute response time. One of the determining factors is the climate of the community concerned. Morris (1993, pp. 2) states, “studies indicate we can expect flashover to occur in approximately five to seven minutes after open flame occurs.”

Whether the fire stays small or becomes large is dependent on available fuels, construction methods, and adequate oxygen. Often the only additional variable that the fire department’s suppression group can address is the amount of time the fire has to develop. Addressing this issue Peterson (1991, pp. 10-43) states, “The first five minutes of most fires is the determining factor as to whether that fire will remain a small fire or become a large fire.”

Often when fire apparatus drivers know they have long response distances, safety considerations take a second place and can endanger both responders and citizens. Cote and Bugbee (1979) state that the five-minute response guideline must not come at the expense of safety.

### **Effects Response Times Have on Loss of Life and Property - Flashover**

Fires progress in a geometric manner where a doubling of time normally results in a multiplication of fire damage greater than two. Conservation of life and property is best served by mitigation prior to flashover. Mittendorf (1986) states that the primary cause of life and property loss is flashover’s sudden change from a tenable atmosphere with good visibility and moderate heat to an atmosphere where death occurs within seconds.

Coleman (1988, pp. 120) stated the following:

Considering that the time required for flashover in structural fires with standard fuels is typically about seven minutes, the apparatus and firefighters must arrive and get operating very quickly. If it takes a resident two or three minutes to discover and report a fire and three minutes for the apparatus to be dispatched and arrive, the sizing up and initial attack need to be done in a minute or two, or the typical fire will have grown significantly in size. An unconscious person with depleted oxygen will typically suffer permanent brain damage after approximately four minutes. All of this needs to be considered within the context of multiple alarm fires and simultaneous alarms. Delayed response and understaffed response appear inevitable under those circumstances, unless planning is complete.

### **Fuel Load**

Plastics generate more heat per pound than natural components. Plastics rapidly generate more dense smoke that causes responders and occupants to become disoriented, thereby unable to find exits before flashover occurs. Dunn (1990, pp. 54) makes the point that, “Today’s synthetic furnishings – drapes, rugs, chairs, tables, and beds – are more dangerous when they burn than were the home furnishings of 30 years ago.” Increased use of combustible wall coverings has contributed to earlier flashover and increased the occurrence of flashover.

### **Truss Construction**

Truss construction utilizes lightweight cost effective materials to span roof and floor spaces. Almost all structures built in Ames in the last twenty years have some truss components. Routley (1989, pp. 50) states, “To meet a one-hour fire rating, a truss assembly relies almost entirely on its fire resistive ceiling to keep the fire out of the truss space. Once the fire penetrates

the lower membrane, the endurance of the assembly can be measured in minutes, usually very few minutes.”

One of the dangers wood truss construction poses when exposed to fire relates to the method used to construct the truss itself. Fornell (1995, pp. 44) states, “Remember, as heated gusset plates pull away from wood members, the roof or floor might remain in place, only to fail when vibration or firefighters’ weight overloads the weakened assembly.”

Floor, ceiling, and roof trusses change the manner and available time for fire attacks. It places greater emphasis on early attack with adequate water supply. Mittendorf (1991, pp. 51) lists the three principal hazards related to truss construction as, “weak roof, early failure rate, collapse without warning.” Incident commanders need to remember that a roof too dangerous to work on should never be worked under.

Time available for occupant evacuation in residential, commercial and industrial buildings is reduced in any truss-constructed structure. Brannigan (1989, pp. 80) makes the point that, “A truss is a truss. Light wood, heavy timber, steel, or wood and steel combinations are equally hazardous. There are many kinds of trusses. From a construction perspective, they all share the same basic advantages, which are disastrous disadvantages for firefighters.”

The literature review identifies our industry’s recommendation of five minutes for response times. Additional information on fuel loads and modern construction methods add significant justification that a five-minute response time is more important today than in the past.

## **PROCEDURES**

The purpose of the research was to prepare recommendations relating to response times, as a part of the citywide emergency response plan, to be presented to the City Manager by August of 1998. The literature review was historical research. It focused on two primary areas: First, to identify standards and recommendations for response times and second, to determine possible effects of response times on life and property loss.

The literature review used began at the National Fire Academy's (NFA) Learning Resource Center (LRC) in April of 1998. Additional material was obtained through Fire Service Institute (FSI) at ISU and a library maintained by the AFD.

The research was action research, in that the resulting information, was utilized to make recommendations for improving the delivery of emergency services to persons residing in and visiting Ames. A component of delivery of services is the response time necessary to arrive at the incident.

Interviews were conducted with Brian O'Connell, Director of Planning and Housing for the City of Ames, and Ray Anderson, Planner for the City of Ames, on April 22, 1998. The interviews were conducted to gain additional insights to the City's Land Use Policy Plan (LUPP), adopted on August 22, 1997, and to obtain their projections of growth not included in the LUPP or developed after the LUPP's adoption.

Site sharing with private sector and cross-jurisdictional partners was evaluated. The AFD's administrative team established a list of potential private industry or governmental agencies. Possible site partners were evaluated by:

1. Compatibility of services
2. Site accessibility requirements

3. Building design requirements
4. Capability to contribute to funding construction
5. Compatibility of schedules for construction

Since 1983, the AFD has collected data as part of the National Fire Incident Reporting System (NFIRS). Reports from the NFIRS are generated using Fire One software from Forge Technologies Inc. Reports were generated for the years 1983 through 1997. Total calls, fire calls, and non-fire calls for each year in the fifteen-year period provided data for trend analysis.

Trends and projections were calculated for an eighteen-year period, from 1998 to 2015. Projections and trends were calculated using Microsoft Excel spreadsheet. Excel's trend function syntax is TREND(known\_y's, known\_x's, new\_x's, constant) and is used to provide linear growth trends.

An additional method for projecting incident growth was developed using the increase in population as the basis for incident call increases. Utilizing projected population increases from the LUPP as the basis for call increases eliminates the increases in calls due to the addition of services offered for non-fire calls in the last 15 years. Future increases were calculated for non-fire calls by dividing the resident population by the 1997 non-fire call figure. The frequency of non-fire calls to population was then applied to projected populations to calculate the projection for non-fire calls through 2015.

An analysis of the present station locations and their effect on response times was conducted. The City of Ames maintains a Geographic Information System (GIS). The GIS has a computer-mapping program from ESRI called ArcView. The AFD purchased a software extension from ERSI called Arc Network. Arc Network allows line street maps to be used for emergency response planning.

The GIS was utilized to calculate distances from present and proposed sites to neighborhood nodes. Two hundred thirty-nine neighborhood nodes were established. The nodes were established by dividing the city into four quadrants. Within each quadrant, nodes were centered in areas of approximately four blocks. The size of the area containing each node varied by geographic barriers, street access, population, and land use. Target zones were also identified and prioritized using the assessor's code for occupancy use. Each land parcel has a corresponding land use code. Target zones were defined as high density residential, hospital, university, commercial, and industrial land use. Parcels identified as target zones were numbered as specific neighborhood nodes. Nodes were used to validate the formula used to calculate response time boundaries.

The GIS produced E-size color-coded land use maps with fire department response zones delineated by an outline of the response district's perimeter. Mapping the land use by assessor's code and overlaying the response identified whether adequate coverage was obtained in the scenarios considered. The E-size maps were produced for presentations to the city administration and are not included in this report. Tabloid size representations, 11" by 17", of the E-size maps are included in appendices G to P.

Distances were converted to time estimates based upon the formulas developed in the Rand Fire Project (Chiken, 1979, pp. 166). When distances are under .38 miles, the formula is  $E(T_{ij}) = 2.10\sqrt{D_{ij}}$ , and when distances are over .38 miles, the formula is  $E(T_{ij}) = 0.65 + 1.70D_{ij}$ . When the distance is .38 miles, either formula results in the same time estimate.

The GIS system then calculated all possible routes from the present and proposed locations to the nodes located in neighborhoods throughout the four quadrants. The computer would then plot the run districts and produce run district maps.



Test runs were conducted to verify the accuracy of the calculated distances. Ten percent of the neighborhood nodes were tested. The GIS calculated the run district for the existing stations. Node points at the extreme edge of the calculated run district were selected. Test runs were conducted on July 8, 1998 and July 9, 1998. Runs were conducted between 14:00 and 18:30 in order to sample pre-peak, peak, and post-peak traffic periods.

In order to evaluate present and potential response times, five possible station location scenarios were developed by the AFD's administrative staff:

Scenario #1

Keep current station locations.

Scenario #2

Keep current station locations with rail crossings closed.

Scenario #3

Keep Station #1 at the current location, close Station #2 and build two new stations.

Scenario #4

Keep Station #1 at the current location, close Station #2 and build three new stations.

Scenario #5

Close both existing stations and build four new stations.

**Limitations**

The study was limited to fire incident response and does not include emergency medical response considerations. The AFD has a partnership with Mary Greeley Medical Center (MGMC) for emergency medical response where the AFD provides first-in basic life support and limited advanced life support. Current talks conducted by the City Manager's office in conjunction with administrative personnel from MGMC may significantly affect the final recommendations for future station locations.

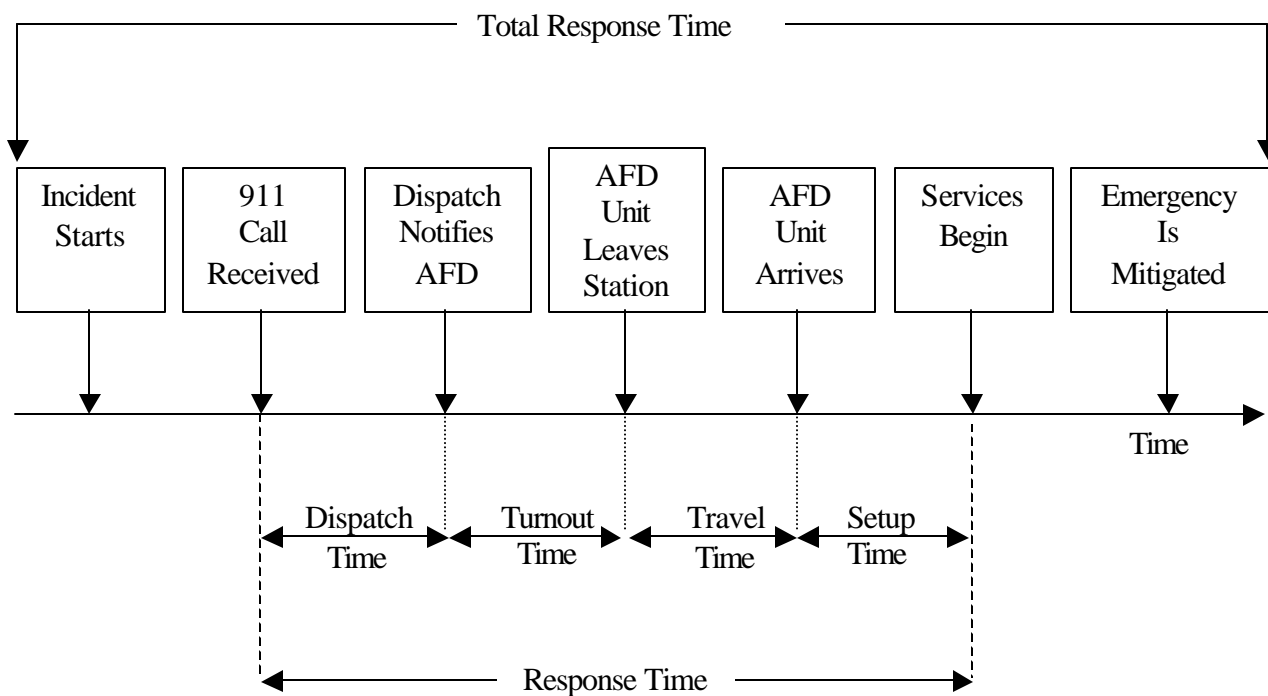
Issues related to response times including specific site selection, manning, station configurations, and apparatus acquisition are not included in this report.

Population estimates are based upon census data for residents and LUPP population projections. Statistics for daytime populations including visitors, employees who work in Ames and live elsewhere, non-resident ISU students, medical patients, and business customers are not available.

The research was limited to the effects of station locations and their corresponding travel time to response areas defined by neighborhood nodes. Chiken's (1979, pp. 83) definition of total response time includes a broader definition as illustrated in Table 3.

Table 3

Definition of response time components



Training and standard operating guidelines can shorten response time by adequately addressing dispatch time, turnout time, and setup time. This research is limited to the station's location and its corresponding travel time.

### **Definition of Terms**

Response Times - Amount of time, in minutes, from AFD notification by Ames Police Dispatch to moment when response vehicle arrives curbside on scene.

Total Response Time - A measurement of time from the start of the emergency to its termination. Total response time includes time prior to reporting, notification, time in station before unit leaves, travel time, operations setup, operations, and ends at termination.

Flashover - The sudden ignition of exposed combustible surfaces and/or combustible gases in an involved area that results in a sudden and intense rise in temperature.

Fire Calls - The emergency response incidents where damages were incurred due to the presence of uncontrolled fire. The largest categories are structure and vehicle fires.

Non-fire Calls - Emergency response calls where fire was not present. The largest categories are Emergency Medical Response, response to automatic fire alarms, and carbon monoxide detection.

## **RESULTS**

The applied research results include: 1) findings of the literature review addressing regulations, standards, and fire service hazards; 2) observations from interviews with personnel from the Ames' Planning and Zoning Department; 3) details of the AFD administrative meeting to determine potential site-sharing partners; 4) analysis of NFIRS data with trends and projections; 5) presentation of GIS data for the five station location scenarios.

### **Literature Review Results**

Travel time, a component of total response time, is an important variable that is not currently legislated. Recommendations vary from three to six minutes depending on level of service standards established by the administration of the community.

Response times are typically broken into the four components listed in Table 3. Travel time would normally comprise one to four minutes of response time. Dispatch time, turnout time, and setup time typically add two minutes to travel time and complete the sum for response time.

Quick action is necessary in order to preserve life and property. Flashover changes a tenable atmosphere to a lethal atmosphere. The availability of fuel, oxygen, and buildup of heat may be beyond the control of the fire service, but the amount of time before mitigation can be addressed through planning, adequate procedures, and strategically located resources.

A contributing factor to the decrease in time when flashover occurs is the increased fuel loads in modern occupancies. The increased use of synthetics for coverings and components has significantly increased the heat and smoke produced over natural components.

Lightweight construction techniques typically include the use of truss construction. Truss construction reduces building costs and decreases the time until structural collapse occurs during fires.

All trusses have similar characteristics. The failure of a single component in an individual truss can cause load shifting that poses significant chance of total system failure. There are not significant differences in how varying types of trusses react to fire exposure.

The literature review verifies the need for quick response to today's occupancies for the purpose of mitigating fires prior to flashover. A decrease in time to flashover occurs due to increased fuel loads. Light weight construction methods utilizing truss construction causes a decrease in time for escape and interior operations due to structural collapse.

### **Interviews, Planning and Zoning**

On August 22, 1997, the Ames Planning and Zoning Department completed the LUPP. Interviews with the department head, Brian O'Connell, and Ray Anderson, Planner for the City of Ames, added significant insight to the LUPP's report. In the year 2001, the Planning and Zoning Department will update the LUPP.

Ames' role is changing from a local commercial center to one of a more regional scope. Mass merchandisers are locating on the high traffic edges of the community in the hope of attracting high volume traffic. The addition of commercial business on the fringes of the city limits, places additional burdens for adequate response times, compounded by a larger number of visitors and their potential need for services.

Commercial Centers are designated in the LUPP as follows:

1. Highway-Oriented Commercial (Neighborhood/Community-scale) - Commercial uses that are associated with strip developments along major thoroughfares. Customers are normally from the local neighborhood.

Examples – A. Lincoln Way from Grand east to the Skunk River and Duff

Ave from the railroad to Hwy 30

B. Airport road, Hwy 30, Duff North to Squaw Creek

C. Green Hills area

D. West Lincoln Way and county line road area

E. West Lincoln Way from the 3200 block to 4200 block

2. Community Commercial Node (Community-scale) - Commercial uses that are associated with cluster developments and that, compared with Highway-Oriented Commercial, have more specific uses, shared parking and common design features. Customers are normally from the community or traveling through the community for other reasons.

Examples – A. Campustown – Existing

B. NW corner of 13<sup>th</sup> and Dayton – Planned with approval in weeks

C. NE corner of Hwy 30 and South Dakota – planned with development occurring in 3 to 5 years, after highway 30 intersection is installed

D. Intersection of North Dakota and extended Bloomington

Road – part of the NE growth area (conditional on several factors and developed in excess of fifteen years)

3. Regional Commercial (Regional-scale) - Commercial uses that are associated with major retail and service centers near limited-access thoroughfares. Customers normally travel from within the community and from outside the community to conduct business or shop.

Examples – A. North Grand Mall

B. East of Interstate 35 bound north by Lincoln Way (old Hwy 30) and approximately 1/4 mile south of new Hwy 30

4. Downtown Services Center - Specialized business services, governmental services and retail commercial uses that are associated with highly intense activities and central location. Specialized mixing of activities, parking and design provisions may apply. Customers are often a mix of neighborhood, community and regional.

Examples – A. Downtown Ames

Ames has adopted the LUPP with the intention of prioritizing growth through the allocation of infrastructure in a manner to facilitate growth while planning for adequate services.

The major growth or residential areas are designated as:

1. The SW growth area – first to be developed – designated as village/suburban residential. North border is the railway.
2. NW growth area – development within 20 to 30+ years depending on utilization of the SW growth area and ISU making land available in the SW growth area.

Brian O’Connell pointed out the LUPP projection for annual growth rates of between .5% to .6% annually. Since the time when the LUPP was adopted, commercial growth and future projections have met the LUPP projections and may exceed the original expectations.

Due to the development of the Barilla site and the extension of water and sewer east of Interstate 35, a new area for development is possible. The area is quite vast and could extend as far as Nevada. A more likely prediction would be East of Interstate 35 for two miles, north one mile past old Lincoln Way, and south one mile of Highway 30.

Ray Anderson presented information contained in a draft report titled “Summary of Existing Transportation System Deficiencies”(Barton, Aschen, 1998, pp.15). Train traffic on Duff Avenue and Dayton Road prevents normal access to the southeast quadrant of Ames. Table 4 shows the current and the year 1999 anticipated train traffic:

Table 4

Anticipated increase in rail traffic and train length

| <b>Year</b> | <b>Trains per Day</b> | <b>Trains per Hour</b> | <b>Hours per Day Crossings Closed</b> | <b>Percent of Time Daily Crossings are Closed</b> | <b>Number Of Cars per Train</b> |
|-------------|-----------------------|------------------------|---------------------------------------|---|---------------------------------|
| 1998        | 66                    | 2.75                   | 3.05                                  | 12.7%   | 120                             |
| 1999        | 100                   | 4.2                    | 4.6                                   | 19.2%   | 150                             |

Train traffic in Ames presents daily potential for significant fire department emergency response delays. Several possible solutions for the train delays are being considered. All of the suggestions involve large capital expenditures and will take substantial time to implement. A suggestion made at the meeting was to develop future station location scenarios that would place the first in company at locations where they could not be blocked by train traffic.



### **Potential Site Sharing Partners**

On April 24, 1998, a meeting was held with Chief Michael T. Childs, Deputy Chief of Support, Phil L. Harris, and Deputy Chief of Operations, Clint Petersen. Using the criteria described in this report's procedures, a list of potential site-sharing partners was developed.

Part of the discussion focused on how the selection of a site-sharing partner would affect the type of station constructed. Examples of the various station types follows:

1. Traditional single station with limited space for secondary occupancy
2. Residential type construction where station blends into predominately residential neighborhood
3. Strip mall construction where station is located in one or more bays typical of modular strip mall construction
4. Industrial or commercial construction type of station where a larger entity shares part of its space with the department

Several ideas concerning potential site-sharing partners were discussed. The list is limited to potential site-sharing partners who have expressed an interest, or are currently considering construction, or control property that initially is in a location of interest to the department. A list of potential site-sharing partners follows:

1. Mary Greeley Medical Center
2. Iowa State University Fire Service Extension
3. Story County Sheriff
4. Ames Public Works
5. Ames Convention and Visitors Bureau
6. United States Army Reserve

**Ames Fire Department National Fire Incident Reporting System Data**

The analysis of AFD emergency calls started with historical data from 1983 to 1997.

Calls were categorized as total calls, fire calls, and non-fire calls. Fire call and non-fire call percentages were calculated and the sum equals total calls.

Population information for years 1983 to 1997, obtained through the LUPP, was included to facilitate analysis of the number of fire and non-fire calls divided into the population. Table 5 shows the number, percentage of total, and population divided by call type.

Table 5Historical NFIRS Data for AFD

| <b>Year</b> | <b>Population</b> | <b>Total Calls</b> | <b>Fire Calls</b> | <b>Fire Call %</b> | <b>Residents per Fire Call</b> | <b>Non-Fire Calls</b> | <b>Non-Fire Call %</b> | <b>Residents per Non-Fire Call</b> |
|-------------|-------------------|--------------------|-------------------|--------------------|--------------------------------|-----------------------|------------------------|------------------------------------|
| 1983        | 45,251            | 508                | 119               | 23%                | 380                            | 389                   | 77%                    | 116                                |
| 1984        | 45,524            | 541                | 138               | 26%                | 330                            | 403                   | 74%                    | 113                                |
| 1985        | 45,799            | 585                | 157               | 27%                | 292                            | 428                   | 73%                    | 107                                |
| 1986        | 46,075            | 600                | 156               | 26%                | 295                            | 444                   | 74%                    | 104                                |
| 1987        | 46,354            | 780                | 165               | 21%                | 281                            | 615                   | 79%                    | 75                                 |
| 1988        | 46,633            | 795                | 164               | 21%                | 284                            | 631                   | 79%                    | 74                                 |
| 1989        | 46,915            | 788                | 164               | 21%                | 286                            | 624                   | 79%                    | 75                                 |
| 1990        | 47,198            | 767                | 155               | 20%                | 305                            | 612                   | 80%                    | 77                                 |
| 1991        | 47,468            | 788                | 127               | 16%                | 374                            | 661                   | 84%                    | 72                                 |
| 1992        | 47,739            | 839                | 167               | 20%                | 286                            | 672                   | 80%                    | 71                                 |
| 1993        | 48,009            | 986                | 127               | 13%                | 378                            | 859                   | 87%                    | 56                                 |
| 1994        | 48,280            | 1,164              | 181               | 16%                | 267                            | 983                   | 84%                    | 49                                 |
| 1995        | 48,550            | 1,232              | 186               | 15%                | 261                            | 1,046                 | 85%                    | 46                                 |
| 1996        | 49,091            | 1,316              | 199               | 15%                | 247                            | 1,117                 | 85%                    | 44                                 |
| 1997        | 49,639            | 1,385              | 189               | 14%                | 263                            | 1,196                 | 86%                    | 42                                 |

Table 5 data reveals a 10% increase in population and a 273% increase in total calls. Fire calls increased by 59% and non-fire calls increased by 307%.

In 1983, an average of one person in 380 was involved in a fire call. 1997 involved an average of one person in 263 in a fire call.

In 1983, an average of one person in 116 was involved in a non-fire call. 1997 involved an average of one person in 42 in a non-fire call.

Linear trend analysis was used to analyze total calls, fire calls, and non-fire calls through the year 2015. The year 2015 was used to maintain consistency throughout this report. Table 6 population growth estimates were obtained through the LUPP.

Table 6

Projections of call levels based upon linear growth trend calculations

| <b>Year</b> | <b>Population</b> | <b>Total Calls</b> | <b>Fire Calls</b> | <b>Fire Call %</b> | <b>Residents per Fire Call</b> | <b>Non-Fire Calls</b> | <b>Non-Fire Call %</b> | <b>Residents per Non-Fire Call</b> |
|-------------|-------------------|--------------------|-------------------|--------------------|--------------------------------|-----------------------|------------------------|------------------------------------|
| 1998        | 49,970            | 1,357              | 187               | 14%                | 267                            | 1,170                 | 86%                    | 43                                 |
| 1999        | 50,301            | 1,418              | 190               | 13%                | 264                            | 1,227                 | 87%                    | 41                                 |
| 2000        | 50,633            | 1,478              | 194               | 13%                | 261                            | 1,285                 | 87%                    | 39                                 |
| 2001        | 50,964            | 1,539              | 197               | 13%                | 258                            | 1,342                 | 87%                    | 38                                 |
| 2002        | 51,295            | 1,600              | 201               | 13%                | 256                            | 1,399                 | 87%                    | 37                                 |
| 2003        | 51,626            | 1,660              | 204               | 12%                | 253                            | 1,456                 | 88%                    | 35                                 |
| 2004        | 51,957            | 1,721              | 207               | 12%                | 251                            | 1,514                 | 88%                    | 34                                 |
| 2005        | 52,288            | 1,782              | 211               | 12%                | 248                            | 1,571                 | 88%                    | 33                                 |
| 2006        | 52,620            | 1,842              | 214               | 12%                | 246                            | 1,628                 | 88%                    | 32                                 |
| 2007        | 52,951            | 1,903              | 218               | 11%                | 243                            | 1,685                 | 89%                    | 31                                 |
| 2008        | 53,282            | 1,964              | 221               | 11%                | 241                            | 1,743                 | 89%                    | 31                                 |
| 2009        | 53,613            | 2,024              | 224               | 11%                | 239                            | 1,800                 | 89%                    | 30                                 |
| 2010        | 53,944            | 2,085              | 228               | 11%                | 237                            | 1,857                 | 89%                    | 29                                 |
| 2011        | 54,275            | 2,146              | 231               | 11%                | 235                            | 1,914                 | 89%                    | 28                                 |
| 2012        | 54,607            | 2,206              | 235               | 11%                | 233                            | 1,972                 | 89%                    | 28                                 |
| 2013        | 54,938            | 2,267              | 238               | 11%                | 231                            | 2,029                 | 89%                    | 27                                 |
| 2014        | 55,269            | 2,328              | 242               | 10%                | 229                            | 2,086                 | 90%                    | 26                                 |
| 2015        | 55,600            | 2,388              | 245               | 10%                | 227                            | 2,143                 | 90%                    | 26                                 |

Table 6 data from the LUPP estimates a 11% increase in population and the linear trend a 76% increase in total calls. Fire calls could increase by 31% and non-fire calls increase by 83%.

In 1998, an average of one person in 267 could be involved in a fire call. 2015 trends involve an average of one person in 227 in a fire call.

In 1998, an average of one person in 43 could be involved in a non-fire call. 2015 trends involve an average of one person in 26 in a non-fire call.

Linear growth trend analysis represents the high end of expectations for growth of AFD calls. From 1983 to 1997, the AFD increased the number of service programs offered to Ames citizens. Some of the increase in non-fire calls and total calls was due to the increased emergency

response implemented during the fifteen-year period. The high rate of increased offerings is not expected to continue at a linear rate.

Additional analysis was conducted using the increase in population, as the basis for an increase in total calls by adopting the assumption that without increases in services the ratio of people involved in non-fire calls to the population will stabilize at the 1997 ratio. Table 7 projects an increase in total calls that is based upon the increase in LUPP estimates of population.

Table 7

Projections of call levels based upon population increases

| <b>Year</b> | <b>Population</b> | <b>Total Calls</b> | <b>Fire Calls</b> | <b>Fire Call %</b> | <b>Residents per Fire Call</b> | <b>Non-Fire Calls</b> | <b>Non-Fire Call %</b> | <b>Residents per Non-Fire Call</b> |
|-------------|-------------------|--------------------|-------------------|--------------------|--------------------------------|-----------------------|------------------------|------------------------------------|
| 1998        | 49,970            | 1,377              | 187               | 14%                | 267                            | 1,190                 | 86%                    | 42                                 |
| 1999        | 50,301            | 1,388              | 190               | 14%                | 264                            | 1,198                 | 86%                    | 42                                 |
| 2000        | 50,633            | 1,399              | 194               | 14%                | 261                            | 1,206                 | 86%                    | 42                                 |
| 2001        | 50,964            | 1,411              | 197               | 14%                | 258                            | 1,213                 | 86%                    | 42                                 |
| 2002        | 51,295            | 1,422              | 201               | 14%                | 256                            | 1,221                 | 86%                    | 42                                 |
| 2003        | 51,626            | 1,433              | 204               | 14%                | 253                            | 1,229                 | 86%                    | 42                                 |
| 2004        | 51,957            | 1,444              | 207               | 14%                | 251                            | 1,237                 | 86%                    | 42                                 |
| 2005        | 52,288            | 1,456              | 211               | 14%                | 248                            | 1,245                 | 86%                    | 42                                 |
| 2006        | 52,620            | 1,467              | 214               | 15%                | 246                            | 1,253                 | 85%                    | 42                                 |
| 2007        | 52,951            | 1,478              | 218               | 15%                | 243                            | 1,261                 | 85%                    | 42                                 |
| 2008        | 53,282            | 1,490              | 221               | 15%                | 241                            | 1,269                 | 85%                    | 42                                 |
| 2009        | 53,613            | 1,501              | 224               | 15%                | 239                            | 1,277                 | 85%                    | 42                                 |
| 2010        | 53,944            | 1,512              | 228               | 15%                | 237                            | 1,284                 | 85%                    | 42                                 |
| 2011        | 54,275            | 1,524              | 231               | 15%                | 235                            | 1,292                 | 85%                    | 42                                 |
| 2012        | 54,607            | 1,535              | 235               | 15%                | 233                            | 1,300                 | 85%                    | 42                                 |
| 2013        | 54,938            | 1,546              | 238               | 15%                | 231                            | 1,308                 | 85%                    | 42                                 |
| 2014        | 55,269            | 1,557              | 242               | 16%                | 229                            | 1,316                 | 84%                    | 42                                 |
| 2015        | 55,600            | 1,569              | 245               | 16%                | 227                            | 1,324                 | 84%                    | 42                                 |

Table 7 data from the LUPP estimates a 11% increase in population and projects a 14% increase in total calls. Fire calls could increase by 31% and non-fire calls increase by 11%.

In 1997, an average of one person in 267 could be involved in a fire call. 2015 projections involve an average of one person in 227 in a fire call.

Table 7 utilizes the assumption that without increasing service programs the ratio of residents involved in non-fire calls would stabilize at the 1997 figure of 42.

Table 6 represents the high end of anticipated call growth and table 7 represents the low end of anticipated call growth. As of June 30, 1998, call rates increased 2.5% over the same period in 1997.

### **Geographic Information System Results**

The GIS calculated all routes possible from the existing station locations and proposed station locations. Validation of the calculated response times was conducted by performing test runs to the perimeter of the calculated response districts from existing stations. Test runs were conducted starting at each of the two existing stations. Thirteen runs from Station #1 and 10 from Station #2 provided a 10% sample of the 239 neighborhood nodes. Actual times were within 1.8% of the calculated times. Test runs confirmed that the formulas used to calculate distance did represent the conditions found in Ames. Appendix E shows test run results for Station #1. Appendix F shows test run results for Station #2.

The GIS calculated the five-minute response districts for each scenario and their associated statistics in the listed areas:

1. Number of neighborhood nodes covered
2. Acres covered

The GIS calculation of acres included in the current city boundaries is 13,747 acres. The GIS estimate, utilizing the LUPP for the southwest growth area, of total acres in the Ames Planning District by the year 2015 is 16,306. Neighborhood nodes were arranged on the GIS base map for reference points. Current city boundaries included 191 neighborhood nodes and 239 neighborhood nodes are included in the LUPP projections for the year 2015. Geographic boundaries, land use, target zones, or population density allocated neighborhood nodes. Results of the five scenarios follow:

Scenario #1 - Keep current station locations

In the current city limits, 154 of the 191 neighborhood nodes, or 81%, are within the five-minute response goal. Five-minute response to the current city limits area of 13,747 acres can be reached for 10,612 acres or 77% of the total.

In the Ames Planning District, 169 of the 239 neighborhood nodes, or 70%, are within the five-minute response goal. Five-minute response to the city's planning area of 16,301 acres can be reached for 11,261 acres or 69% of the total.

Appendix G displays the outline of response districts and land use. Appendix H displays the neighborhood nodes inside of five minutes in green and outside of five minutes in red.

Scenario #2 - Keep current station locations with railroad crossings closed

In the current city limits, 148 of the 191 neighborhood nodes, or 78%, are within the five-minute response goal. Five-minute response to the current city limits area of 13,747 acres can be reached for 10,340 acres or 75% of the total.

In the Ames Planning District, 163 of the 239 neighborhood nodes, or 68%, are within the five-minute response goal. Five-minute response to the city's planning area of 16,301 acres can be reached for 10,988 acres or 67% of the total.

Appendix I displays the outline of response districts and land use. Appendix J displays the neighborhood nodes inside of five minutes in green and outside of five minutes in red.

Scenario #3 - Keep Station #1 at the present location, close Station #2 and build two new stations

In the current city limits, 168 of the 191 neighborhood nodes, or 88%, are within the five-minute response goal. Five-minute response to the current city limits area of 13,747 acres can be reached for 11,956 acres or 87% of the total.

In the Ames Planning District, 192 of the 239 neighborhood nodes, or 80%, are within the five-minute response goal. Five-minute response to the city's planning area of 16,301 acres can be reached for 13,017 acres or 80% of the total.

Appendix K displays the outline of response districts and land use. Appendix L displays the neighborhood nodes inside of five minutes in green and outside of five minutes in red.



Scenario #4 - Keep Station #1 at the present location, close Station #2 and build three new stations

In the current city limits, 180 of the 191 neighborhood nodes, or 94%, are within the five-minute response goal. Five-minute response to the current city limits area of 13,747 acres can be reached for 12,717 acres or 93% of the total.

In the Ames Planning District, 220 of the 239 neighborhood nodes, or 92%, are within the five-minute response goal. Five-minute response to the city's planning area of 16,301 acres can be reached for 14,526 acres or 89% of the total.

Appendix M displays the outline of response districts and land use. Appendix N displays the neighborhood nodes inside of five minutes in green and outside of five minutes in red.

Scenario #5 - Close both existing stations and build four new stations.

In the current city limits, 191 of the 191 neighborhood nodes, or 100%, are within the five-minute response goal. Five-minute response to the current city limits area of 13,747 acres can be reached for 13,747 acres or 100% of the total.

In the Ames Planning District, 231 of the 239 neighborhood nodes, or 97%, are within the five-minute response goal. Five-minute response to the city's planning area of 16,301 acres can be reached for 15,555 acres or 95% of the total.

Appendix O displays the outline of response districts and land use. Appendix P displays the neighborhood nodes inside of five minutes in green and outside of five minutes in red.

Table 8 summarizes the results of analysis of five-minute response coverage by neighborhood nodes and acres for LUPP projections of Ames in 2015.

Table 8

Summary of GIS results for five-minute response districts for current city limits

| Year 1998       | Total 191 Nodes                 |                         | Total Acres 13,747 |                         |
|-----------------|---------------------------------|-------------------------|--------------------|-------------------------|
| Scenario Number | Neighborhood Nodes in 5 Minutes | % of Nodes in 5 Minutes | Acres in 5 Minutes | % of Acres in 5 Minutes |
| 1               | 154                             | 81%                     | 10,612             | 77%                     |
| 2               | 148                             | 78%                     | 10,340             | 75%                     |
| 3               | 168                             | 88%                     | 11,956             | 87%                     |
| 4               | 180                             | 94%                     | 12,717             | 93%                     |
| 5               | 191                             | 100%                    | 13,747             | 100%                    |

Table 9 summarizes the results of analysis of five-minute response coverage by neighborhood nodes and acres for LUPP projections of Ames in 2015.

Table 9

Summary of GIS results for five-minute response districts based upon LUPP projections for

2015

| Year 2015       | Total 239 Nodes                 |                         | Total Acres 16,306 |                         |
|-----------------|---------------------------------|-------------------------|--------------------|-------------------------|
| Scenario Number | Neighborhood Nodes in 5 Minutes | % of Nodes in 5 Minutes | Acres in 5 Minutes | % of Acres in 5 Minutes |
| 1               | 169                             | 70%                     | 11,261             | 69%                     |
| 2               | 163                             | 68%                     | 10,988             | 67%                     |
| 3               | 192                             | 80%                     | 13,017             | 80%                     |
| 4               | 220                             | 92%                     | 14,526             | 89%                     |
| 5               | 231                             | 97%                     | 15,555             | 95%                     |

## DISCUSSION

Modern construction methods utilizing lightweight truss construction are identified in the literature review as posing significant hazards to occupants and responders when exposed to fire. In the last twenty years, Ames has had significant growth in residential and commercial use of truss construction. Truss construction coupled with increased fuel load from synthetic components and furnishings has increased the need for fast intervention and mitigation.

Brannigan (1979) makes the point that “a truss is a truss.” The material of construction does not matter; when a member of a component system fails, the whole system is prone to fail. The AFD has encountered truss failure in residential and commercial settings.

A five-minute response time for fire calls is not a legislated requirement but one adopted by the majority of American cities the size of Ames. The LUPP has been a valuable resource for planning municipal services including emergency response to fire calls. The anticipated growth will be in areas currently outside of a five-minute response. Recent and future commercial and industrial construction on the outskirts of town will increase call numbers to areas with longer response times.

Planning and Housing Director Brian O’Connell expressed the opinion that eastern expansion of commercial and industrial sites may exceed the projections of the LUPP. The response times to the Barilla plant currently under construction east of Interstate 35 are in excess of 7 minutes.

Increased use of Campustown facilities poses a significant problem for emergency responses from Station #2. When it was initially built, the site was the edge of an older retail center. The LUPP designates Campustown as a Community Commercial Node. Recent infrastructure improvements by the city and private enterprise show a long-term commitment to

increase vehicular and pedestrian traffic. Delays caused by increased traffic pose a significant threat to residents needing emergency response and to persons in the emergency response travel path. A majority of the apparatus responses from Station #2 travel through one of the busiest intersections of Ames at Welch and Lincoln Way.

Increased rail traffic extends the hours per day the crossings are closed from the current 3.05 hours to 4.6 in 1999. Response vehicles encountering the Duff Avenue crossing closed, adds response times from one to five minutes for the southeast quadrant of Ames.

Site-sharing partners have been identified that have the potential to decrease initial and continuing costs. MGMC and the AFD have shared responsibility for emergency medical responses. MGMC would make compatible services available from a shared facility. The possibility exists of increased service program development through increased interaction with MGMC paramedics.

ISU FSI is presently in the early stages of a campaign to build a new fire training facility. Richard Arwood, Executive Officer of ISU FSI, has expressed an interest in pursuing a shared facility. The compatibility of services with ISU FSI and similarity of necessary facilities for housing and training make ISU FSI a prime candidate for site sharing.

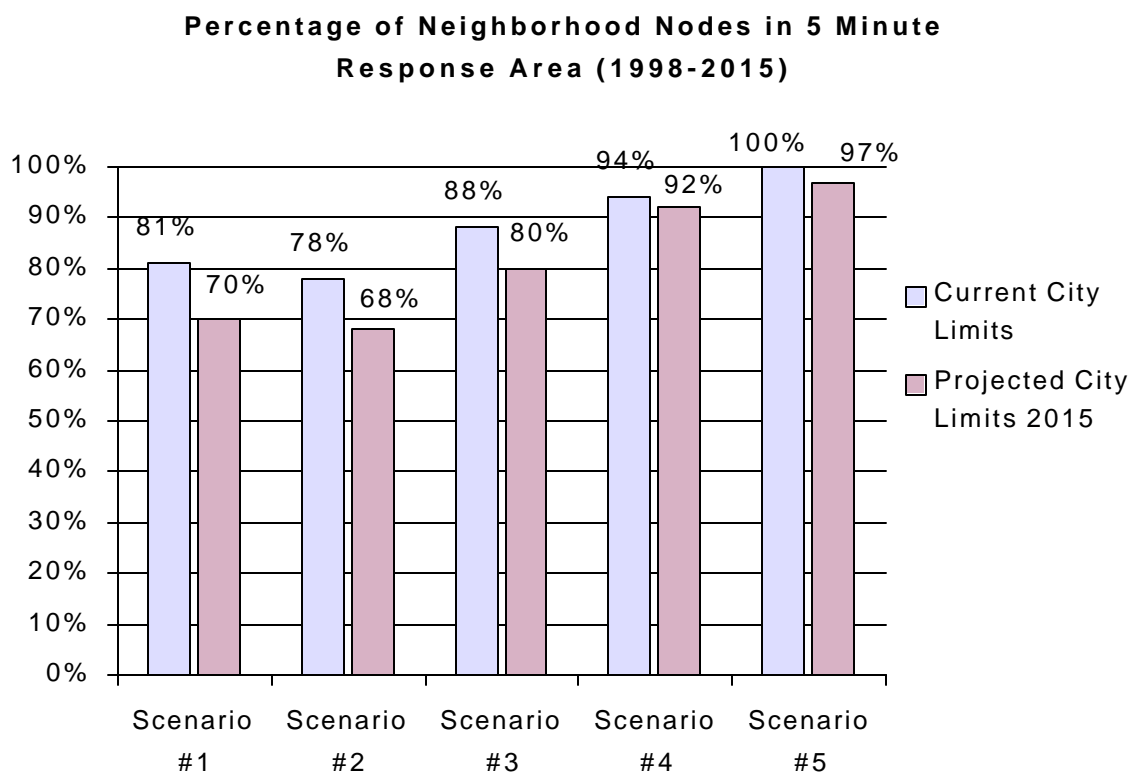
Analysis of NFIRS run data for the AFD indicates continued call growth by the year 2015 of 14% to 76%. The 76% increase is based upon a straight growth trend model and may not take into account the increased service program growth of the prior 15 years. Predicting a growth rate based upon population increase ignores the trend in actual fire call increase that occurred between 1983 and 1997. Responses to actual fire calls had no increase in service programs or changes in reporting methods that may have affected the incurred increase of 59%. Predictions of

emergency response call increases are best expressed as a range from the population growth calculation of 14% and the linear growth trend calculation of 76%.

Presently 70% of neighborhood nodes for areas in the LUPP Ames Planning District lie within the five-minute response goal. Closely associated to the analysis of neighborhood nodes is the analysis of acres covered. The present locations provide five-minute response to 69% of the total acres estimated by the GIS as being within the Ames Planning District. Together the neighborhood node and acres covered analysis constitutes the present response times for 1998 and beyond.

Figure 1 graphically displays current and LUPP projections for the year 2015 as percentages of neighborhood nodes covered for all five scenarios.

Figure 1



The current station configuration is represented in both Scenario #1 and Scenario #2. The difference is in Scenario #2, where it is assumed the railroad crossings encountered during emergency response calls are closed. Five-minute response times diminish by 3% from 81% to 78% when rail traffic blocks emergency apparatus routes.

Scenario #3, closing station #2 and building two new stations, improves current five-minute response coverage to 88% and eliminates rail traffic considerations for first in apparatus. By the year 2015 a three-station department would be able to provide emergency five-minute emergency response to 80% of the community.

Scenario #4, is the four-station option with existing Station #1 held in its current location. Five-minute response times cover 94% of the current city limits and 92% of the projected neighborhood nodes in 2015. The weakness of this scenario is coverage of new industrial areas east of Interstate 30. Moving Station #1 involves abandoning a modern facility with a substantial investment.

Ames' daytime population is thought to be substantially higher than the resident population. The responsibility of emergency services for visitors, employees who work in Ames and live elsewhere, non-resident ISU students, medical patients, and business customers has increased as Ames became, and continues to increase its role of, a regional commercial center. With the movement, or new establishment, of Highway Oriented Commercial and Regional Commercial centers to locations on the present city boundaries, the ability for the AFD to provide adequate emergency services response has and will continue to decline.

By closing Station #2 and building at two new sites, for a total of three stations, the percentage of neighborhood nodes and acres covered would increase to 80%. This report does not recommend specific site selection. It is the opinion of the author that additional analysis of

potential sites for a three-station scenario may move the five-minute response districts to as high as 84%.

Implications of this research show the need for further study of specific site selection for station locations. The goal of a five-minute response time is defensible and should be adopted. Based upon LUPP population and area growth projections, present station locations provide decreasing response time coverage. The three station scenario may provide adequate emergency fire response for short-term. Based upon the LUPP projections for the year 2015, a fourth station will be necessary.

## **RECOMMENDATIONS**

Further research should be conducted to prepare recommendations for new station construction. Specific site selection, the addition of EMS considerations, manning, apparatus, station construction design, and costs should be prepared for presentation to the city administration, council, and public.

Although this report recommends proceeding with new station construction, no additional recommendations should be developed without including Emergency Medical Services. Dialogues with MGMC should be initiated so future research includes first in response for Advanced Life Support. The relationship between MGMC and the AFD for Emergency Medical Services should be clarified pertaining to areas of responsibility, initial and continuing costs, manning, training, apparatus, supplies, and equipment.

The adoption of a five-minute response goal for fire suppression is recommended. After clarification of the AFD's role in Emergency Medical Service has been completed, through dialogues with MGMC, the five-minute response goal may need to be lowered to four minutes.

Station recommendations follow:

1. Close Station #2.
2. Build three new stations.

Station #2 should be closed after construction of the three new stations is complete. The current status of covering 81% of the existing city limits will decline to 70% in the next 17 years. By moving to a four-station department the immediate need for adequate coverage improves to 94%. By the year 2015 the five-minute response coverage will decline under a four-station scenario to 92%.

Ames could establish a three station temporary fix for locations so a fourth station can be added without larger then necessary costs. One method may be to build a third station with a planned fourth station. If a site could be obtained that provided acceptable immediate response times and was located appropriately for a fourth station, future moves and additional construction could be avoided. As of this time there is no site recommendation that provides adequate response times for both a three-station department and a future four-station department.

Another method to transition from a three-station location to four presents a more favorable solution. Based upon LUPP projections, Station #2 can be located in the NW quadrant in position for the foreseeable future. Station #3 could be located to address the short-term needs of Ames for a five-minute response goal. Station #3 costs could be limited through cooperation with site-sharing partners. When a future growth justifies the addition of a fourth station, Station #3 would be relocated.



The AFD should start preliminary discussions with site sharing partners. Site sharing can reduce the initial and continuing costs associated with the establishment of new stations. ISU FSI and MGMC are strong potential partners. Compatibility of services, plans for expansion, and expressed interest make ISU FSI and MGMC high priority options from the list of potential partners developed in this research.

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## APPENDIX A

### POPULATION PROJECTIONS

City of Ames Planning Area and Story County 1990-2030

|             | <b>City of Ames Planning Area</b> |             | <b>Story County</b> |             |
|-------------|-----------------------------------|-------------|---------------------|-------------|
| <b>Year</b> | <b>Low</b>                        | <b>High</b> | <b>Low</b>          | <b>High</b> |
| 1990        | 50,000                            | 50,200      | 74,252              | 74,252      |
| 1995        | 51,850                            | 52,300      | 76,180              | 78,180      |
| 2000        | 53,750                            | 54,400      | 78,400              | 80,400      |
| 2005        | 55,700                            | 56,500      | 80,700              | 82,700      |
| 2010        | 57,600                            | 58,600      | 83,100              | 85,100      |
| 2015        | 59,500                            | 60,800      | 85,600              | 87,600      |
| 2020        | 61,400                            | 62,900      | 88,100              | 90,000      |
| 2030        | 65,000                            | 67,000      | 94,000              | 96,000      |

## APPENDIX B

### HOUSING PROJECTIONS

City of Ames/Planning Area and Story County 1990-2030

|             | <b>City of Ames<br/>Planning Area</b> |             | <b>Story County</b> |             |
|-------------|---------------------------------------|-------------|---------------------|-------------|
| <b>Year</b> | <b>Low</b>                            | <b>High</b> | <b>Low</b>          | <b>High</b> |
| 1990        | 17,200                                | 17,300      | 26,847              | 26,847      |
| 1995        | 18,300                                | 18,500      | 29,000              | 29,800      |
| 2000        | 19,000                                | 19,200      | 29,900              | 30,700      |
| 2005        | 19,700                                | 20,000      | 30,800              | 31,600      |
| 2010        | 20,400                                | 20,700      | 31,700              | 31,500      |
| 2015        | 21,000                                | 21,500      | 32,600              | 33,400      |
| 2020        | 21,700                                | 22,200      | 33,600              | 34,400      |
| 2030        | 25,000                                | 25,800      | 35,800              | 36,600      |

## APPENDIX C

### LAND USE PROJECTIONS

City of Ames/Planning Area 1994-2030

|                  | <b>1994</b> |      | <b>2030</b> |      |             |      |
|------------------|-------------|------|-------------|------|-------------|------|
| <b>Land Use</b>  |             |      | <b>Low</b>  |      | <b>High</b> |      |
| Residential      | 9,103       | 17%  | 10,800      | 20%  | 11,150      | 21%  |
| Commercial       | 732         | 1%   | 1,530       | 3%   | 1,630       | 3%   |
| Industrial       | 852         | 2%   | 1,150       | 2%   | 1,230       | 2%   |
| Public           | 5,489       | 10%  | 5,620       | 10%  | 5,670       | 10%  |
| Parks/Open Space | 1,851       | 3%   | 2,250       | 4%   | 2,300       | 4%   |
| Other            | 36,081      | 67%  | 32,785      | 61%  | 32,128      | 59%  |
| Totals           | 54,108      | 100% | 54,108      | 100% | 54,108      | 100% |

## APPENDIX D

### LAND USE POLICY PLAN

Projections for population growth and National Fire Incident Reporting data from 1983 to 1997

| <b>Year</b> | <b>Population</b> | <b>Total Calls</b> | <b>Fire Calls</b> | <b>Fire Calls as a<br/>% of Total<br/>Calls</b> | <b>Non-Fire Calls</b> | <b>Non-Fire Calls as a<br/>% of Total Calls</b> |
|-------------|-------------------|--------------------|-------------------|---|-----------------------|---|
| 1983        | 45251             | 508                | 119               | 23%   | 389                   | 77%   |
| 1984        | 45524             | 541                | 138               | 26%   | 403                   | 74%   |
| 1985        | 45799             | 585                | 157               | 27%   | 428                   | 73%   |
| 1986        | 46075             | 600                | 156               | 26%   | 444                   | 74%   |
| 1987        | 46354             | 780                | 165               | 21%   | 615                   | 79%   |
| 1988        | 46633             | 795                | 164               | 21%   | 631                   | 79%   |
| 1989        | 46915             | 788                | 164               | 21%   | 624                   | 79%   |
| 1990        | 47198             | 767                | 155               | 20%   | 612                   | 80%   |
| 1991        | 47481             | 788                | 127               | 16%   | 661                   | 84%   |
| 1992        | 47766             | 839                | 167               | 20%   | 672                   | 80%   |
| 1993        | 48053             | 986                | 127               | 13%   | 859                   | 87%   |
| 1994        | 48341             | 1164               | 181               | 16%   | 983                   | 84%   |
| 1995        | 48691             | 1232               | 186               | 15%   | 1046                  | 85%   |
| 1996        | 48983             | 1316               | 199               | 15%   | 1117                  | 85%   |
| 1997        | 49277             | 1385               | 189               | 14%   | 1196                  | 86%   |

**APPENDIX E****TEST RUN RESULTS FOR STATION #1**

| <b>Run #</b> | <b>Node</b> | <b>Time(sec.)</b> | <b>Distance</b> | <b>Feet/Sec.</b> | <b>4 Minute</b> | <b>Distance</b> | <b>Feet/Sec.</b> |
|--------------|-------------|-------------------|-----------------|------------------|-----------------|-----------------|------------------|
| 1            | 144         | 277               | 14,764          | 53.30            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 11,994          | 49.98            |
| 2            | 245         | 211               | 13,409          | 63.55            |                 |                 |                  |
|              |             |                   |                 |                  | Run<4 Min.      | -               | -                |
| 3            | 249         | 250               | 13,462          | 53.85            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 12,650          | 52.71            |
| 4            | 235         | 240               | 13,534          | 56.39            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 13,534          | 56.39            |
| 5            | 306         | 288               | 14,637          | 50.82            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 11,926          | 49.69            |
| 6            | 308         | 277               | 14,560          | 52.56            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 12,844          | 53.52            |
| 7            | 320         | 266               | 14,082          | 52.94            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 12,843          | 53.51            |
| 8            | 419         | 302               | 15,765          | 52.20            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 12,843          | 53.51            |
| 9            | 421         | 240               | 13,510          | 56.29            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 13,510          | 56.29            |
| 10           | 410         | 262               | 15,342          | 58.56            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 13,187          | 54.95            |
| 11           | 419         | 235               | 13,700          | 58.30            |                 |                 |                  |
|              |             |                   |                 |                  | Run<4 Min.      | -               | -                |
| 12           | 416         | 226               | 14,080          | 62.30            |                 |                 |                  |
|              |             |                   |                 |                  | Run<4 Min.      | -               | -                |
| 13           | 131         | 273               | 15,051          | 55.13            |                 |                 |                  |
|              |             |                   |                 |                  | 240             | 13,546          | 56.44            |



**APPENDIX F**  
**TEST RUN RESULTS FOR STATION #2**

| Run # | Node | Time(sec.) | Distance | Feet/Sec. | 4 Minute   | Distance | Feet/Sec. |
|-------|------|------------|----------|-----------|------------|----------|-----------|
| 1     | 201  | 273        | 13,604   | 49.83     |            |          |           |
|       |      |            |          |           | 240        | 12,048   | 50.20     |
| 2     | 220  | 261        | 14,189   | 54.36     |            |          |           |
|       |      |            |          |           | 240        | 13,535   | 56.40     |
| 3     | 225  | 251        | 14,265   | 56.83     |            |          |           |
|       |      |            |          |           | 240        | 13,520   | 56.33     |
| 4     | 312  | 336        | 18,115   | 53.91     |            |          |           |
|       |      |            |          |           | 240        | 13,158   | 54.83     |
| 5     | 325  | 224        | 14,490   | 64.69     |            |          |           |
|       |      |            |          |           | Run<4 Min. | ██████   | ██████    |
| 6     | 363  | 253        | 14,150   | 57.35     |            |          |           |
|       |      |            |          |           | 240        | 13,818   | 57.58     |
| 7     | 337  | 213        | 13,272   | 62.31     |            |          |           |
|       |      |            |          |           | Run<4 Min  | ██████   | ██████    |
| 8     | 458  | 237        | 13,694   | 57.78     |            |          |           |
|       |      |            |          |           | Run<4 Min  | ██████   | ██████    |
| 9     | 437  | 279        | 14,960   | 53.62     |            |          |           |
|       |      |            |          |           | 240        | 14,128   | 58.87     |
| 10    | 410  | 320        | 16,183   | 50.57     |            |          |           |
|       |      |            |          |           | 240        | 12,351   | 51.46     |